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Low Bit-Rate Coding/Transmission of Remotely Sensed Larger Image Signals and their useful Information extraction

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ABSTRACT

This paper deals with two interesting application areas of Physics: Signal Processing and Electronics. For the first area; particularly image signal coding for efficient transmission or low memory consumed storage and the signal's information identifying techniques were focused. The low cost, LED display panel was used to display final results. Paper is based on the first stage results of the project for designing of an automated electronic system for coding, transmitting, decoding, data extraction and result displaying of remotely sensed large size image/video still frame signals. The law bit-rate information preserving coding of passive sensor acquired such image signals is one of the major problem for updating the GIS (Geographical Information System), for useful Hiperspectral or Multispectral imaging signal processing and object identification tasks.

Here, a modified codec based on the Quadtree Subband Coding Method [1] was implemented. For the 3-D Hyperspectral signal used for surveillance applications, band wise coding approach was introduced and acceptable PSNR values (above 29.14 dB) for very-Low to higher bit rate coding were observed with acceptable quality HVS perception. For the 2-D "Gold hill" test image signal used for urban planning, fairly better window observation results were obtained at larger Compression Rate (CR=80); the coded/decoded image at 0.1bpp. For the next step, Morphological and enhancing techniques were innovatively implemented for identifying faces in the 2-D image signal; "People-gathering".

1. INTRODUCTION

Now a days, Machine Vision and related passive sensor acquired image or video signal processing applications are essential for planning, managing and utilizing the global resources as well in order to avoid the security threats in national and international levels.

Remotely sensed Larger size 2-D and 3-D image signals obtained either using observation aircrafts (e.g. AVIRIS[2]) or satellites have to be efficiently coded, transmitted in less time for updating GIS (Geographical Information System) which used for urban planning, Meteorology, Military or surveying applications, GPS (Geological positioning System), Metrology/Climatology data bases or in order to use for deserter preventive analysis and Hiperspectral or Multispectral imaging signal processing tasks used for agriculture (vegetation analysis) or geographical analysis on earth etc. Not only the on-board acquired image signals, but also the on-ground security system camera head transducers acquired video frame signal sequences are massive in size. Therefore, the enhanced signal processing techniques for information preserving coding of the video frame signals, transmission, low memory consumed storage and the needy information extraction/detection from the still video frame images are needed. Moreover, the finally analyzed or extracted results from such systems have to be displayed in low cost, locally fabricated wider screens than the normal size LCD or TV screens.

For the above mentioned image/video signal processing, transmission, analysis requirements, the hardware and software based sophisticated total automated solutions are less available in the literature as well the cost is unbearable for a developing country like Sri Lanka. Also, an efficient bit stream codec based low memory consumed signal processing hardware implementation was proposed in [1], based on the advanced Electronics research laboratory facility conditions of a foreign university. Such designs based signal processing electronic systems have to be adopted locally using low cost available component resources and with further research.

The initial stage results of the project for designing of an automated electronic system for remotely or at distance sensed large size image/video still frame signal processing and for the hardware implementations are primarily focused in this paper.

2. METHODOLOGY

The initial stage methodology flow diagram for the information preserving low-bit-rate coding, transmission (or low memory consumed storage) and the needy information extraction/identification from the interested image signals can be illustrated as in Figure 1.

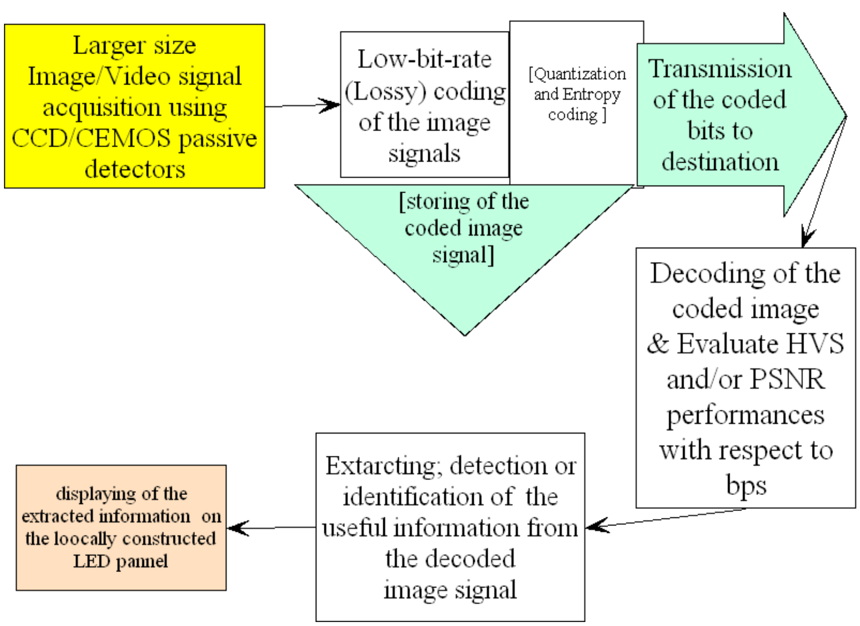

Figure 1: The initial stage methodology flow diagram for the proposed system

2.1 The theoretical backgrounds behind the implementations

Human eyes or optical image acquisition systems are sensitive to catch *image signals*, which consisted of variety of object edge details and which are often two-dimensional light signals received from a scene. It is obvious fact that a continuous sensor acquired analogue signal is not suitable for computer processing. Therefore, it is necessary to convert the acquired image signals to digital form through the processes of sampling and quantization. A 2-D image signal consists of pixels of spatial axis while a 3-D Hyperspectral remote sensing image signal consists of spatially related pixels and spectrally related frequency bands. Varieties of specific object edges present in 2-D and 3-D image signals are used in various applications.

In the process of image signal coding, the removal/minimization of redundant information representing binary bits are performed. Therefore, the coding reduces the size of the digital image. Basically, an efficient codec [1] based on the technique of dividing and sub-dividing quadrants within an image plane, hence a quad-tree can be generated that identifies differences and similarities within a quadrant.

The object extraction/ detection signal processing process: The system based (automatic) recognition of a face includes the detection and segmentation of facial feature, the normalization of facial feature, face representation and face recognition [3].
In order to identify face information from the gray scale decoded image signal; "People-gathering", initially one of the Morphological signal processing operation called Hat Transformation (HT) was used with modifications.

The Top Hat Transformation (h) of an image can be defined by

$$h = f - (f \circ b) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

,where f is 2-D input image signal and b is the structuring element function.

This transformation is useful for enhancing the details (especially disk/ cylindrical shape flat tops) in the presence of shading. Hence the modified version of HT with image signal subtraction was used to achieve more visibility of face like objects.

Here, in order to maximize the contrast between the face like objects and also to exaggerate the gaps that separate them from each other, the original image was added to HT transformed image signal. The resultant image signal was denoted by (S). Then the opposite transformation to HT; which contains the intensity "Lows" of objects was subtracted from the above (S) signal. The final result is shown in Figure 6(b).Then, using another technique, image signal enhancement was also performed on the 8bpp coded "People-gathering" image signal. Here, contour shape edges/ boundaries of the face like objects in the image signal were being able to identify. Here, the signal's intensity adjustment technique was preformed before identifying the faces like objects in the sense. The end result is shown in Figure 6(c).

The performance evaluation for the coding, the transmission and the decoding phases of the methodology: The experiments were conducted using HVS (Human Visual System) perception evaluations and by calculating PSNR (Peak Signal to Noise Ratio) (dB) for the coded/decoded bit rates (in bps). In this research work, using the Sub-dividing quad tree based codec solution, the 3-D Hyperspectral band wise coding/decoding qualitative result variation was obtained and analyzed.

2.2 The test image signals used for the coding and the information identifications

Massive size 3-D image signal called "S-Airport" with 38 Megabytes and 126 spectral bands used for ground observations was used to observe the band wise Region of Interest (ROI) coding and decoding performance (Figure 2(b)).

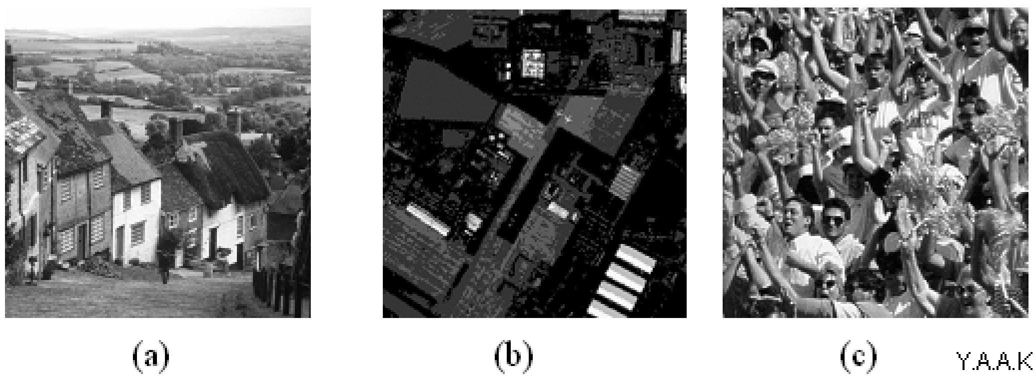

Figure 2: The remotely acquired original image signals: (a) Gold hill (can be used for town planning) (b) First band of 3-D image signal: "S-Airport" coded/Transmitted/ decoded at 8bpp (c)"People-gathering" image acquired at a distance for face identification etc.

2.3 The USB-based, Low Cost Information Displaying LED Panel Technology

The Display device was directly interfaced to the PC (used to process/execute and extract the information of the image signal) via the USB port [4]. The DSP algorithm running on PC decodes predefined targets and then sends digital signals in accordance with a protocol defined to the display device (made using microcontroller controlled LED panel) which would then start displaying the extracted information provided either by the DSP system or manual feed. Four (4)-bit data packets were used for data communication between the DSP system and the display device. Figure 3 is the LED display panel (sequential displaying) used in the initial stage of the project for the proposed system.

Figure 3: The microcontroller controlled LED display panel of the system

3. RESULTS AND DISCUSSION

Continued developments in coding schemes have allowed fairly low bit coding-rates to be achieved before the artifacts become visually apparent, and when they do, the nature of the artifacts are in general less visually objectionable.

The following are the results and observations obtained after coding/transmission/ decoding of three useful remotely sensed image signals. They represent three application aspects deal with signal processing and electronics.

3.1 "Gold hill" 2-D image for Town Planning

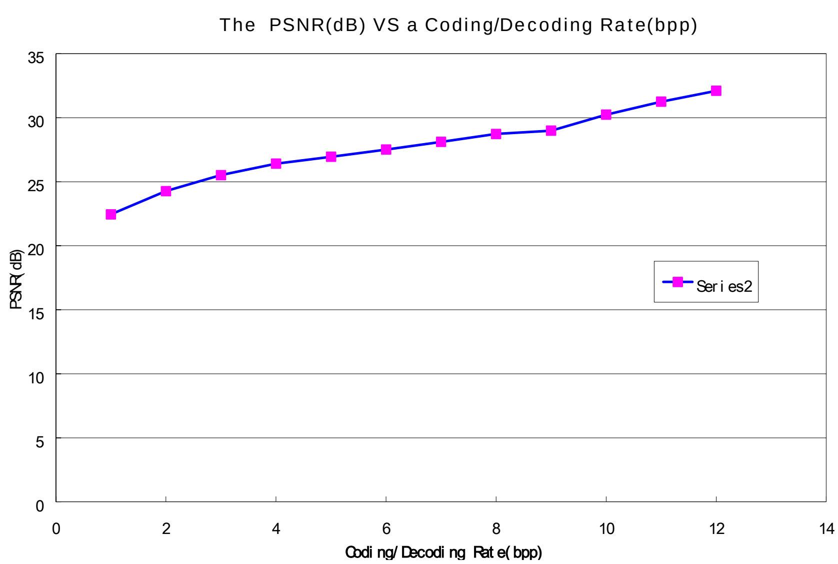

Figure 4: PSNR(dB) results for Low to high bit rate coding/ decoding of "Gold hill"

Table 1: Low- high bit rate coding results PSNR (dB), CR and HVS observations

Coding (bpp)	PSNR(dB)	CR	HVS observation and comments
0.01.	22.45	800	Many artifacts, very difficult to identify
0.03	24.26	267	Difficult to identify
0.05	25.51	160	Fairly visible windows
0.08	26.41	100	visible
0.1	26.95	80	Can count windows, better HVS results
0.12	27.51	67	Can see roof types
0.15	28.11	53	Resolution better, man's direction
0.19	28.73	42	Resolution better
0.21	28.99	38	Objects are clear
0.3	30.23	27	Distance background distinguishable
0.4	31.25	20	Distance background clear
0.5	32.1	16	All information are visible
0.7	33.71	11.4	Better perception ability

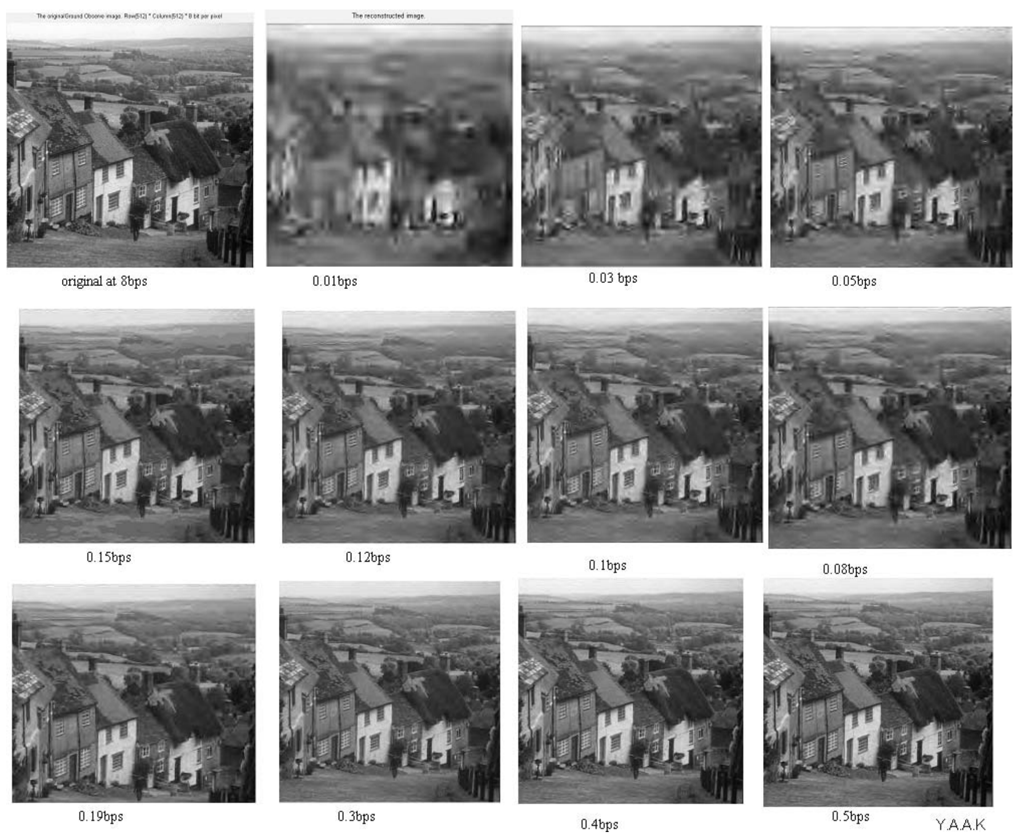

Figure 5: HVS observation results for Low to high bit rate coding/ decoding of image signal (Gold hill)

The decoded image at 1.2 bpp; Figure 5; 2nd column, 2nd image has better HVS observation results. Also, the size of coded bit stream at 0.1bpp was *6.4 times smaller than the original image size*.

3.2 "S-Airport" which can be used for Surveillance or Surveying (GIS based) application

Table 2: band wise PSNR(dB) distribution with the increase of code/decode rates (bpp).

	PSNR(ROI) dB					
Band No.	0.05bpp	0.1bpp	0.3bpp	0.5bpp	0.65bpp	1bpp
1	26.705	29.140	35.261	38.667	41.744	44.007
22	27.802	29.503	35.125	38.099	41.509	43.542
43	28.311	30.253	35.556	38.644	42.029	43.791
64	28.717	31.167	36.445	39.132	42.307	43.971
85	29.016	31.258	36.685	39.308	42.657	44.346

3.3 "People-gathering" acquired for face identification

Here, in Figure 6(b), there were about 12 faces which could be manually identifiable.
In the Figure 6(c), only 10 faces with contour shape object boundaries could be identify; indicated by green color circles.

Therefore, the final results were manually fed and displayed in sequential manner on the constructed LED display.

(a) (b) (c)

Figure 6: (a) The 2-D "People-gathering" image coded/decoded at 8bpp and (b) The modified Hat Transformation applied and decoded image (c) The image signal enhancement technology applied result for extracting faces

4. CONCLUSION

Image and Video signal coding/ transmitting and decoding real-time hardware platforms and their software based codec solutions have to be efficiently implemented locally with low cost and with proper awareness. As, such applications are essential for updating GIS and in order to use with wider scope of local/ global applications deal with surveillance, surveying etc. Moreover, other areas of image signal processing such as image information extraction/identification also have vital importance and applicability for country like Sri Lanka which deal with post-war era. Even at very low; 0.05 bpp coding/transmitting/decoding bit rate, the implemented codec could be used to achieve fairly observable image signal information (; with some artifacts) for "Gold hill". Such low bit rate coded, larger aerial images can be used for the less-critical applications such as agriculture "Greenery Evaluation" signal processing tasks. Even at larger Compression Rate (CR=80); the houses in "Gold hill" and their number of window pans also could be observed at 0.1bpp. This convinces the codec's suitability for town planning image signal coding and transmission applications. The massive size 3-D "S-Airport" were coded at very low bit rate of 0.05bpp (with rectangular ROI mask). Nevertheless, higher PSNR (dB) results (above 29.14 dB) were obtained for each of the five bands concerned. Therefore, such codec based low-cost portable electronic hardware platforms need to be developed.

The final 2-D image signal "People-gathering" sensed at a distance and coded/decoded at 8bps was processed using morphological and signal enhancing modified techniques. This first stage signal processing methods for object identification tasks need to be amalgamated with Neural Network based training and Pattern Recognition advanced concepts in order to achieve better results. Also, the above first stage results were obtained by processing on Pentium-M processor based Microcomputer, with some noticeable time consumption.

Further development and implementation of the discussed signal coding and the other related signal processing technology on more efficient DSP based hardware platforms have to be focused on the next stage of the project.

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